THE RECOVERY OF SPILLED HEAVY OIL WITH SKIMMERS

Prepared for

PRAIRIE REGION OIL SPILL CONTAINMENT AND RECOVERY ADVISORY COMMITTEE

by

ESSO RESOURCES CANADA LTD.

DECEMBER 1988

CANADIAN PETROLEUM ASSOCIATION

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Esso Resources Canada Limited

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H.M. Brown

THE RECOVERY OF SPILLED COLD LAKE CRUDE OIL WITH SKIMMERS

INTRODUCTION

During 1988, a series of experiments was conducted in the Esso Resources wave basin to test various suggested methods of containing and recovering spilled heavy oil from water. Oil from the Cold Lake plant was used in these tests. In addition to this plant, which is a major source of heavy oil, there are other bitumen extraction plants in Northeastern Alberta which also handle significant amounts of the material and transport it over varying distances. Although the chance of an accidental spill is remote, more stringent environmental regulations are likely to require operators of these facilities to demonstrate an ability to recover spilled heavy oil from both the ground and water. The concern with such spills is not confined to plant sites as there is now a large volume of heavy oil with diluent being piped from Cold Lake to Edmonton. A pipeline break may result in the spill of a product in which the diluent will evaporate rapidly to leave a bitumen like material for recovery.

The heavy oil or bitumen extracted from the Athabasca Tar Sands is unique in its physical and chemical properties[1]. It is a very viscous oil containing a high percentage of asphaltenic and polar compounds and possesses a density near that of freshwater. Consequently, the oil has been observed to float or sink (and subsequently refloat) depending on the relative temperature of the water on which it is spilled and the oil temperature.

No spill containment and recovery equipment has been specifically designed to combat spills of this oil but equipment which has been used on spills of Bunker C oil or oil which has been heavily weathered[2] may be applicable. Based on the experience with Bunker C oil[3,4], a series of experiments using nets as containment booms has recently been completed in the Esso wave basin. These suggest that nets may be a simple and useful tool for spilled bitumen containment. Once the oil has been corralled by nets, it may be possible to pull the nets with adherent oil onto a barge with a low freeboard or onto a gently sloping shoreline. One is then faced with the problem of removing the sticky oil from the nets so they can be reused, a problem which has not been investigated experimentally.

Another approach is to use nets as the containment device but to remove oil from the water by some type of skimmer. A number of skimmer designs have been proposed for picking up very viscous oils[5] and some success has been achieved in recovering oils in both test spills and spills of opportunity. The oils involved have usually been Bunker C or oils emulsified by weathering. Probably the most extensively tested heavy oil skimmer design is one developed by British Petroleum but now marketed by Vikoma International Ltd. This design was chosen for tests in the Esso wave basin at low water temperatures. It was also suggested that a rope skimmer might work for these oils at low temperatures and this too was tested.

EXPERIMENTAL

A heavy oil skimmer was supplied for the tests by Vikoma International of Cowes, Isle of Wight, U.K. Esso paid for the air freight from Europe and return. The unit supplied was a derivation of the large Seawoolf model which uses star shaped toothed wheels to pull viscous oil into a collection hopper. The unit tested is shown in Photograph 1. This model (named the Oilwoolf) has a nominal capacity of 10 to 15 tonnes/hour or about half that of the Seawoolf but still weighs a substantial 540 kg. Unlike the Sea Woolf, it is supported by floats and has an integral screw pump for removing the collected oil. This enables the unit to be operated 15 to 20 meters away from a boat or shoreline. It does require a large hydraulic power source to supply the pump motors and disk rotors. It can operate in water as shallow as 0.5m.

The two banks of toothed disks which pull in the oil are shown in Photograph 2. The upper bank is hinged somewhat like a jaw so that any debris which is encountered can be readily pulled into the unit without damage to the toothed disk banks. Behind the disks is a large hopper which is normally below water level and is intended to catch heavy debris. This can be emptied by means of an hydraulically operated door in the hopper bottom. Oil pulled in by the disk banks is expected to float across the hopper and over an adjustable weir into the screw pump at the back of the unit. The weir height can be adjusted remotely. The screw pump provides a positive feed to a 4" exhaust hose which can be attached to a tank on a support boat or the shoreline.

During these tests power was supplied to the unit through hydraulic hoses connected to our wave generator supply. Auxiliary power take-offs were installed on the wave generator power unit for this purpose. Our hydraulic unit is electrically driven and can provide fluid at 150l/min. at 3000psi. This is in excess of the Oilwoolf requirements of about 30l of fluid/min. at 2000psi. The skimmer is controlled remotely by the panel shown in Photograph 3 where hydraulic lines can be seen coming from the power supply and proceeding to the skimmer in the water.

A rope mop skimmer manufactured by Centrifugal Systems Inc. of Houston, Texas was also tested on Cold Lake bitumen. This device, shown in Photograph 4, has a nominal pick up capacity of about 1 tonne/hour.

The wave basin and its ancillary facilities have been frequently described elsewhere[6]. It is basically a large concrete pool 30m by 56m in area with wave boards at one end. For this series of tests waves were not part of the program although the floating characteristics of the skimmer were observed during other experiments in which waves were used.

RESULTS AND DISCUSSION

The Vikoma skimmer was briefly tested with Cold Lake bitumen in June 1988 at the Southampton Oil Spill Response Centre in England. Although no details of the test are available, it is understood that the skimmer operated satisfactorily with oil which had been spilled onto water at about $10^{o}C$. This would imply that the oil viscosity was about 10^{5} cSt. No pickup rates were given however.

During the tests in Calgary the water temperature was $0^{o}C$ and it was necessary to run the wave generator for about 30 minutes to break up the ice cover before an experiment could be started. Air temperatures varied from about $-5^{o}C$ to $+5^{o}C$ during the experiments. Thus conditions were likely to be about the most severe under which a skimmer might still be operable. Cold Lake Crude was heated in the barrel to reduce its viscosity sufficiently for easy pouring and then poured down an inclined plane into the water (Photograph 5). This usually produced a mass of oil, part of which initially floated in a thick sheet, but which slowly coalesced into large globules that sank over a period of several hours. On the basis of published data, the viscosity of the oil would be above 10^{6} cSt at this temperature.

The skimmer was operated on several occasions and a total of $3m^{3}$ of Cold Lake bitumen was spilled into the wave basin. We did not spray any of the oil onto the water surface as was originally intended. During several of the poured oil tests, a sheet of oil similar to what would be produced by spraying was picked up by the skimmer and it was felt that a duplication of this was unnecessary. Photograph 6 shows the skimmer pulling in this type of thick sheet.

In general, the results of the skimmer tests were disappointing. We were unable to determine the skimming rate accurately but estimate it to be 4 to 5 barrels/hour or about 1 tonne/hour. This slow rate arose from several problems with the skimmer. The toothed disk concept worked well in that it pulled the oil into the unit if the oil was floating as a dense mat. Globules of oil had to be pushed with a paddle toward the teeth (Photograph 7) but once engaged were also readily pulled into the skimmer. However, we found that the disk motors were underpowered for this viscosity of oil and ran very slowly when the rated hydraulic pressure was applied. When the screw pump was also turned on, the toothed disks would stop altogether.

A second problem was the design of the debris hopper and weir system. As the Cold Lake bitumen was neutrally buoyant at this temperature, it did not float across the debris hopper and the weir as intended but rather sank in the hopper until this was completely filled. Thus nearly a barrel of oil disappeared into the skimmer before any flowed over the weir into the screw pump chamber. The rate at which the skimmer would pick up this oil was ultimately determined by the speed with which the oil flowed over the weir into the pump chamber. We had considerable difficulty in running the screw pump slowly enough so that it would not cavitate. In fact the pump could only

be run for a few seconds before the chamber was empty of oil. It was then necessary to stop the pump and wait for the oil to slowly refill the chamber before starting the pump again. In this manner we were able to recover some oil. The oil was pumped about 2m above the water surface to barrels on the wave basin wall and this head did not appear to be a factor in the recovery rate.

We did not treat any of the oil with the viscosity modifier 'Elastol'. Although this was originally proposed, we did not feel that the skimmer worked well enough that any change in its efficiency due to the presence of Elastol in the oil could be detected.

To a point, rope skimmers appear to improve in efficiency with increasing oil viscosity. For this reason a small rope skimmer was tested on the recovery of Cold Lake bitumen (Photograph 8). It was deployed at the same time as the Vikoma skimmer and was tried with the same oil slicks and semisubmersed globules. It was singularly unsuccessful in picking up any oil it came in casual contact with. The oil appeared unable to wet the rope sufficiently to stick well. Particularly with semisubmersed globules which appear to have a more weathered viscous skin, the rope was able to brush along them without any adhesion. However, when the oil was physically placed on the rope with a paddle or shovel, adhesion did occur and the unit successfully removed the oil from the water. This viscous oil was also successfully removed from the rope by the wringers although the amounts involved were too low to determine wringer capacity.

CONCLUSION

The concept of toothed disks to snag viscous oil and push it into a collection device, as used by the Vikoma skimmer, appears to viable. Previous tests seem to suggest that the device has worked for oil with a viscosity in the order of 10^5 cSt. However, this particular unit did not work well for oil with a viscosity of greater than 10^6 cSt. Three problem areas were identified:

1. The disk bank motors were not powerful enough to maintain proper speed.
2. The debris hopper and weir system prevented oil from flowing directly to the screw pump.
3. The screw pump could not be run slowly enough to prevent cavitating.

We recommend that the manufacturer be approached to determine if modifications to the current design could be made. The manufacturer has been notified of the results of these tests.

Finally, the rope mop skimmer was not successful in picking up Cold Lake oil at $0^{\circ}C$.

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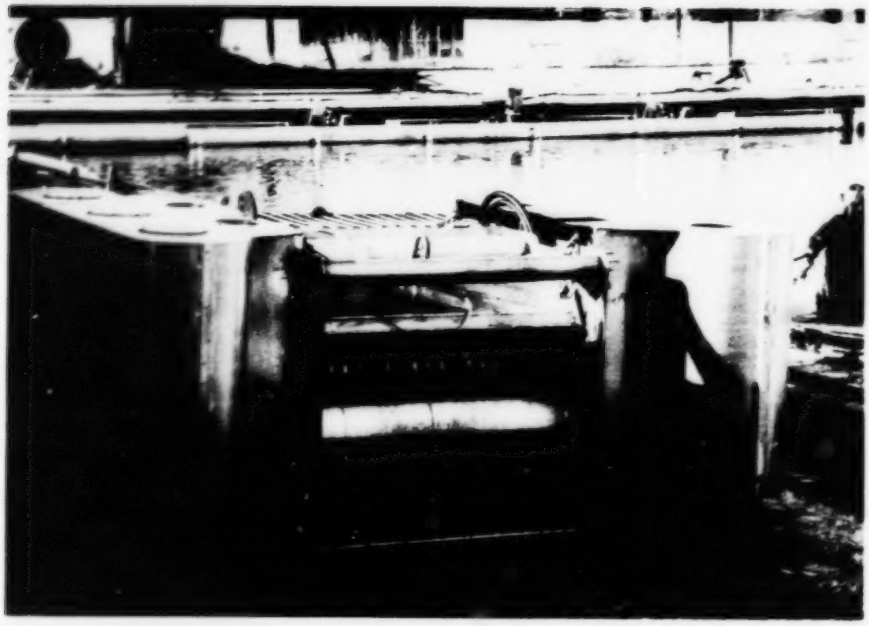

PLATE 1. Front view of Oilwoolf Skimmer

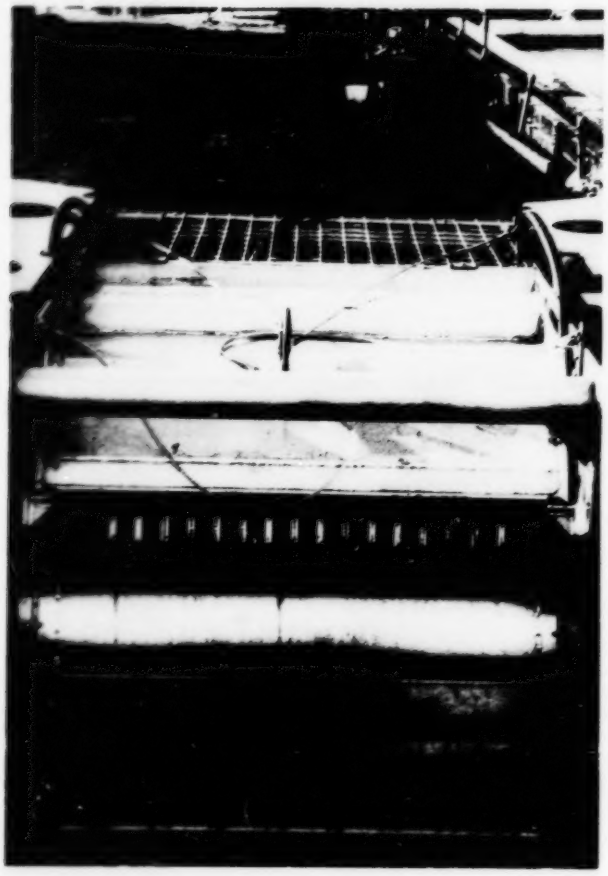

PLATE 2. Close up of toothed disks

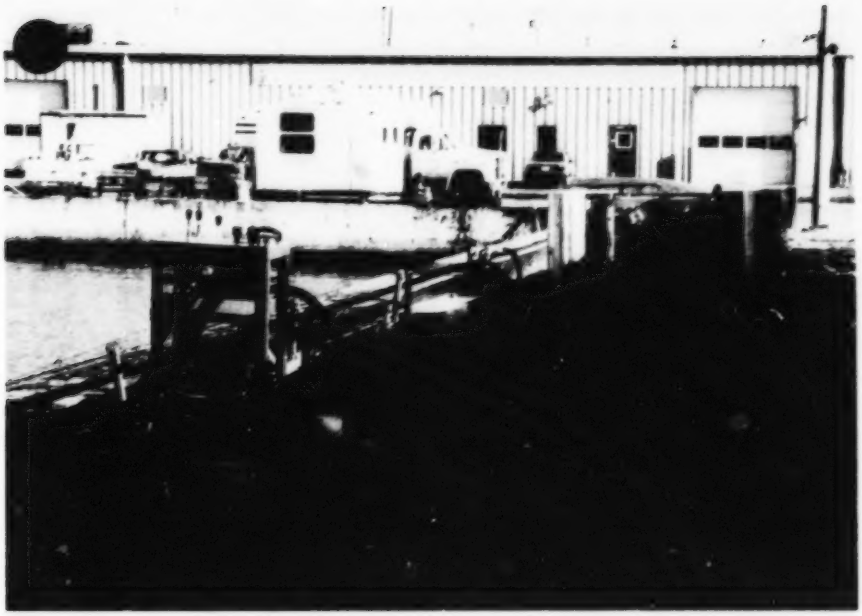

PLATE 3. Control console and hydraulic supply lines

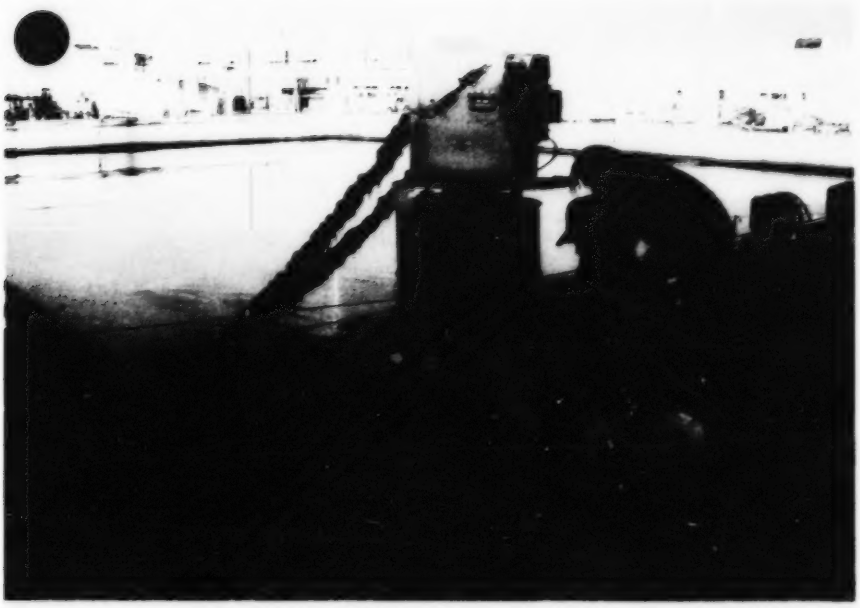

PLATE 4. Centrifugal Systems Inc Rope Mop on collection barrel

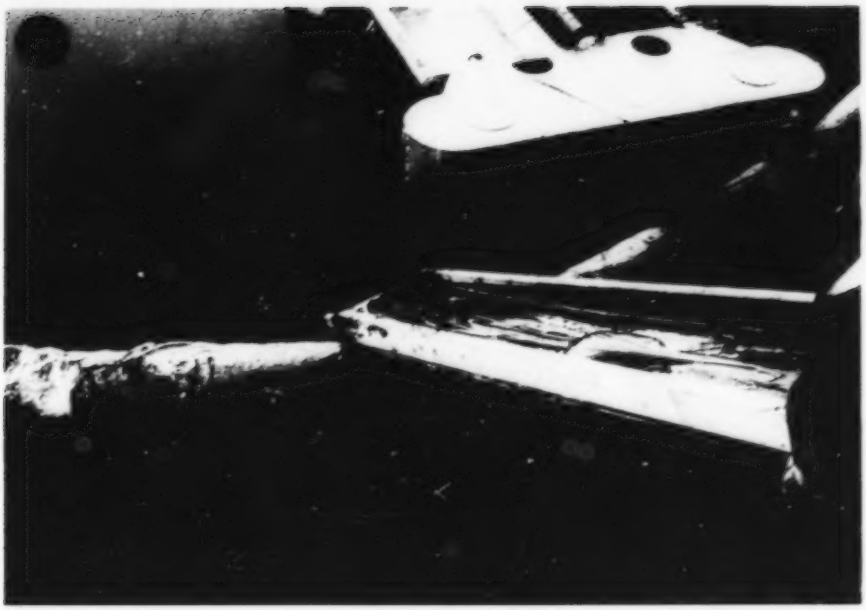

PLATE 5. Cold Lake bitumen being poured onto water surface

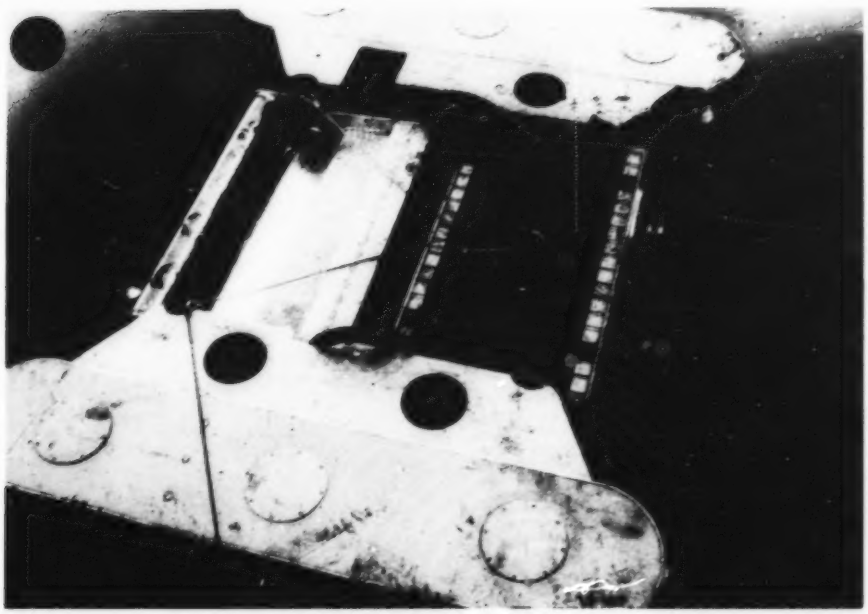

PLATE 6. Tar mat entering skimmer

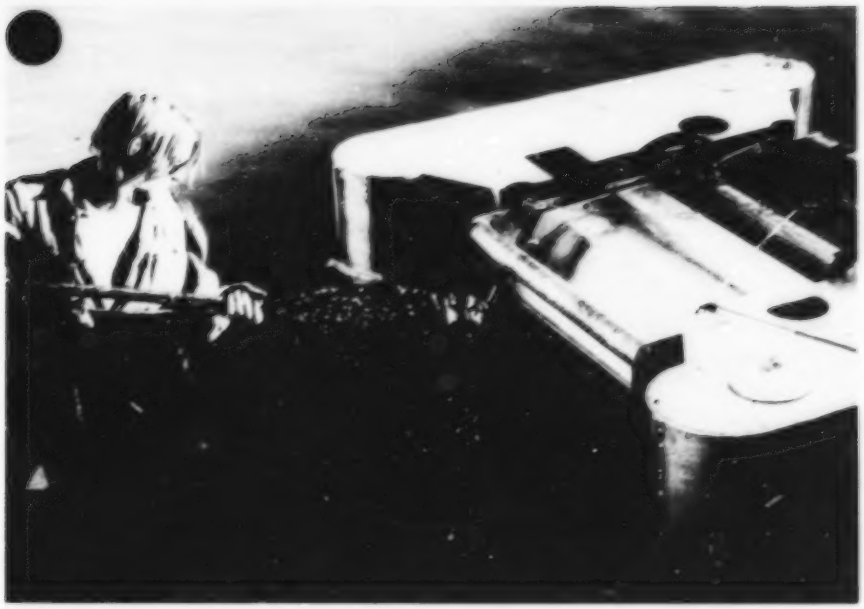

PLATE 7. Large submerged oil globules being pushed toward skimmer

PLATE 8. Ice conditions in wave basin during tests